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ABSTRACT

This study attempts to determine the relationship between individual learning strategies as indicated by measures of levels of divergent thinking and the effectiveness of using inductive or deductive instructional methods in the classroom. Subjects consisted of randomly selected sixth graders who were assigned to two experimental groups or two control groups. Students in the experimental groups were further divided into groups of high divergent and low divergent thinkers. Prior to the treatment both the experimental and control groups were pretested in mathematics and attitude. The treatment consisted of a teacher teaching one experimental group inductively for three weeks while another teacher taught the other experimental group deductively. At the end of three weeks, the two teachers exchanged groups and continued teaching as before for three more weeks. The control groups were taught the same material but in a conventional manner. At the end of this time, all groups were given a posttest in mathematics and attitude. A follow-up test was given at the end of another six weeks period. No significant results were found. [Not available in hardcopy due to marginal legibility of original document.] (FL)

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FINAL REPORT

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A STUDY OF THE EFFECTS OF INDUCTIVE AND DEDUCTIVE TEACHING TECHNIQUES IN ELEMENTARY MATHEMATICS

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October 31, 1970

U.S. DEPARTMENT OF
HEALTH, EDUCATION, AND WELFARE

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A STUDY OF THE EFFECTS OF INDUCTIVE AND DEDUCTIVE TEACHING TECHNIQUES IN ELEMENTARY MATHEMATICS

by

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October 31, 1970

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Mr. David Fitzgerald and Mr. Donald Perry, teaching fellows in Mathematics Education at the University of Houston helped in administering the data-gathering instruments, observed and critiqued the experimental classroom work and helped in preparing the daily lessons. Mr. Fitzgerald was instrumental in designing the inductive lesson plans.

A STUDY OF THE EFFECTS OF INDUCTIVE AND DEDUCTIVE TEACHING TECHNIQUES IN ELEMENTARY MATHEMATICS

I. SUMMARY

Many studies have attempted to define and identify creativity in gifted individuals. Little has been done, however, to determine the effect of individual strategies of learning or learning among the more normal population. Very little seems to have been done toward relating teaching strategies to those characteristic individual strategies of learning.

This study was an attempt to determine the relationship between characteristic individual learning strategies as evidenced by measures of levels of divergent thinking and the effectiveness of using inductive or deductive instructional strategies in actual classroom situations. The primary objectives were as follows:

1. To determine if more highly divergent thinkers among children would respond by greater achievement in mathematics when taught in an essentially inductive--guided discovery instructional strategy than to a primarily deductive--reception orientated teaching strategy;

2. To determine if lower divergent thinking children would respond by greater achievement in mathematics when taught in an essentially deductive reception oriented strategy than to a primarily inductive teaching strategy;

3. To determine the relationship between the achievement of the experimental group and the control group;

4. To determine the relationship of the long-term retention of mathematical knowledge between the control group and the experimental group; and

5. To determine if there was a significant change in attitude between high and low divergent thinkers and between experimental and control group.

The population of the study consisted of 213 randomly selected sixth grade students from the Aldine Independent School District. From these, 108 were randomly chosen as the experimental group and assigned to two teachers. The remaining 105 were assigned to the control group and were assigned to two other teachers. The experimental group was further divided on the basis of their performance on the Torrance Test of Creative Thinking into two groups of high divergent and low divergent thinkers.

Prior to the treatment both the experimental and control groups were pre-tested in mathematics and attitude. The treatment consisted of teacher A teaching one group inductively for three weeks while teacher B was teaching the other experimental group using deductive strategies. At the end of three weeks, teacher A and teacher B exchanged groups and continued teaching as before for the remaining three weeks. At the end of this six week treatment period, both experimental and control groups were administered post tests in mathematics and attitude. At the end of another six week period, a follow-up test in mathematics was administered.

Upon analysis and interpretation of the data, it was found that the treatment had no significant effect on overall achievement between the groups. The subjects, experimental and control, achieved significantly, which was expected. There was, however, no significant difference between the control group and the experimental group in retention of subject matter. Further analysis of the data revealed that there was no significant change of attitude over time interval due to treatment and there appeared to be no significant difference in attitude between the treatment and control groups.

The investigator feels that the lack of significant findings is the result of a treatment period which was too short duration. It is recommended that a study consisting of a treatment period of at least one semester, or better still, a complete academic year be conducted. It is believed that such a study will produce significant results which should have widespread application to improving teaching strategies.

II. INTRODUCTION

A. Statement of the Problem

The Nation, in its struggle for international leadership, has looked to the identification and development of more highly creative individuals. The national goals, however, are not necessarily reflected in the objectives established by teachers. Very few teacher objectives relate to divergent thinking as developed by Guilford.

Many studies have attempted to define and identify creativity in gifted individuals. However, relatively little has been done to determine the effect of characteristic individual strategies of learning on learning among the more "normal" population (those falling within two standard deviations of the population mean). Little or nothing seems to have been done toward relating teaching strategies to those characteristic individual strategies of learning.

For the classroom educator the research findings regarding learning, many of which have been developed in a laboratory setting with necessarily extremely limited number of experimental variables, seem hardly applicable.

Obviously, the myriad social, environmental and non-environmental factors affecting learning come into play in the naturalistic classroom setting. These "interfere" with what might be the pure benefits of specific procedures and effects developed in the experimental laboratories under highly controlled conditions. Factors which are less directly affected by immediate environment such as curiosity, anxiety, dependency, creativity, intrinsic motivation, success drive, reliance on authority and specific achievement no doubt interact within the psyche of the individual to affect not only the degree to which learning takes place, but doubtless the learning processes and strategies themselves.

Consequently, since laboratory conditions may not be duplicated in the normal classroom, the classroom teacher must seek the most effective procedures for him in order to follow a selected teaching strategy. He contends with the factors cited above with specific techniques, which are part of his professional portfolio, or he treats them as random unidentified variables.

It seems clear that children have been instructed according to their learning potential as measured by their I.Q. or achievement level. Some care has often been used to consider their personality types. Rarely has instruction been given according to the characteristic individual strategy of learning of the pupil, i.e., presentation of material according to some dimension of his personal organization for learning.

Many studies, some unfortunately heavily biased, have been conducted to determine if inductive--guided discovery techniques are superior to deductive--

reception methods in teaching. (Reception learning has been defined as arising from teaching where the entire content of what is to be learned is presented to the learner in final form. He is required to "internalize" the material, to make it available and functionally reproduceable for future use. Inductive--guided discovery techniques may be characterized by the presentation of a given array of information in such a manner as to enable the learner to rearrange and integrate it with existing cognitive structure).

The results of these studies are inconclusive. Now, with some of the newer measurements of creativity which discriminate among children's cognitive styles according to a dimension of high and low divergent thinking, it would seem that children who are primarily either high divergent or low divergent thinkers might respond better to either inductive strategies or deductive strategies. There seems to have been no research to either support or refute this.

In the light of the foregoing, it would seem that there is a need for a more definitive investigation to develop new teaching strategies.

One might expect that differences in learning among the less gifted low divergent and high divergent thinkers would also be marked, although perhaps less so than found among highly gifted groups. If this is true, it appears that it would be worthwhile to determine the effects of specific teaching strategies in the "more normal" setting found in schools.

B. Review of Pertinent Literature and Research

Getzels[1] and Torrance[2] found that "gifted" creative children achieve according to cognitive processes including divergence which are different from the cognitive processes of gifted I.Q. children. Although Krumboltz[3] found that there was not a strong interaction of the effects of inductive and deductive methods with I.Q. in college students, there might well be an interaction between these methods and divergence (a key characteristic of creativity) in cognitive processes. Several

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[1] Getzels, Jacob W. and Philip W. Jackson. Creativity and Intelligence. (New York: John Wiley and Sons, Inc., 1962).

[2] Torrance, E. Paul. Education and the Creative Potential. (Minneapolis: University of Minnesota Press, 1963.)

[3] Krumboltz, John D. and William W. Yabroff. "The Comparative Effects of Inductive and Deductive Sequences in Programmed Instruction," American Educational Research Journal, Vol. 2, No. 4, November, 1965.

researchers maintain that children learn more, retain more and change attitudes positively (although the findings are not conclusive through discovery methods).[4,5,6,7]

Carroll reported in 1964 that teaching strategies developed in laboratory settings were very limited in effectiveness when applied to whole groups of children for extended periods.[8]

The results of a study by Krumboltz and Yabroff failed to support the notion that there is a strong interaction of the effects of inductive and deductive methods with intelligence level as measured by I.Q.[9]

Torrance found that children with high creativity scores produced more suggestions for improvement in toys when given the opportunity to actually manipulate the toys than when they only observed them.[10] This concrete experience which would vary with each child according to his own way of manipulating the toys could be looked upon as an inductive process--reasoning through inference.

A significant program to accomplish individually oriented inductive experience, especially in science, has been developed by Suchman.[11] His study established a given strategy for thinking or "inquiring" which proved successful for many students at the elementary school level. It does not, however, indicate or develop the characteristic individual strategy of learning of the student.

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4 Grover, Burton L. "Prediction of Achievement in Divergent and Convergent Learning Situation," Journal of Educational Research, 59:pp. 402-405, 1966.

5 Weaver, J. F. "Differentiated Instruction and School-Class Organization for Mathematical Learning Within the Elementary Grades," Delta News Journal, Delta Campus Chapter Phi Delta Kappa, School of Education, Stanford University, Vol. I, No. 2, June 1966, pp. 19-30.

6 Cronbach, Lee J. "The Logic of Experiments of Discovery," Unpublished Mimeographed Article, 1965.

7 Ausubel, David P. "Some Psychological and Educational Limitations of Learning by Discovery," The Arithmetic Teacher, National Council of Teachers of Mathematics, Vol. II, No. 5, May, 1964.

8 Carroll, John B. "Words, Meanings, and Concepts," Harvard Educational Review, Vol. 34, pp. 178-202, 1964.

9 Krumboltz, John D. and Yabroff, William W., op.cit.

10 Torrance, E. Paul, "Primary Creative Thinking in the Elementary Grades," Elementary School Journal, 62, pp. 34-41, 1961.

11 Suchman, J. R. "Inquiry Training in the Elementary School," Science Teacher, Vol. 27: November, 1960.

C. Objectives

The study was an attempt to determine the relationship between characteristic individual learning strategies as evidenced by measurements of levels of divergent thinking and the effectiveness of using inductive or deductive instructional strategies in actual classroom situations. The primary objectives included the following:

1. To determine if more highly divergent thinkers among children would respond by greater acquisition of mathematical knowledge taught in an essentially inductive--guided discovery instructional strategy than to a primarily deductive--reception oriented teaching strategy;

2. To determine if lower divergent thinking children would respond by the greater acquisition of mathematical knowledge taught in an essentially deductive-reception oriented strategy than to a primarily inductive teaching strategy;

3. To determine the relationship between the achievement of the experimental group and the control group; and

4. To determine the relationship of the long-term retention of mathematical knowledge between the control group and the experimental group;

5. To determine if there was a significant change in attitude between high divergent and low divergent thinkers, and between experimental group and control group.

Accordingly, the following null hypotheses were tested:

H_o1: There will be no significant differences in achievement between high divergent thinkers who are taught in an essentially inductive--guided discovery strategy and those taught in a primarily deductive--reception oriented teaching strategy.

H_o2: There will be no significant differences in achievement between low divergent thinkers who are taught in an essentially inductive--guided discovery strategy and those taught in a primarily deductive--reception oriented strategy.

H_o3: There will be no significant differences in achievement in arithmetic between the experimental group and the control group.

H_o4: There will be no significant difference between the experimental group and the control group on retention of subject matter in mathematics as measured by the follow-up achievement test.

H_o5: There will be no significant differences in attitude changes between high divergent thinkers who are taught in an essentially inductive--guided discovery strategy and those taught in a primarily deductive--reception teaching strategy.

H_o6: There will be no significant differences in attitude changes between low divergent thinkers who are taught in an essentially inductive--guided discovery strategy and those taught in a primarily deductive--reception teaching strategy.

H_o7: There will be no significant differences in attitude changes between the experimental group and the control group.

H_o8: There will be no significant differences in achievement between high divergent and low divergent thinkers.

H_o9: There will be no significant differences in achievement between high divergent thinkers and the control group.

H_o10: There will be no significant differences in achievement between high divergent thinkers and the control group.

H_o11: There will be no significant differences in attitude change between high divergent and low divergent thinkers.

H_o12: There will be no significant difference in attitude change between high divergent thinkers and the control group.

III. METHODS (PROCEDURES)

A. Description of Aldine Independent School District

The Aldine Independent School District is located approximately 20 miles northeast of Houston, and was, until recently, primarily rural. Today, however, it is one of the fastest growing districts in this area, and is primarily residential for people who work in Houston. Very few industries are located in the district, and some of its income is still derived from agriculture.

There are presently 23 schools in the district with a professional staff of 963. The present enrollment is 22,330; however, enrollment increases approximately 1500 each year. Over one-half of the 23 schools are less than 7 years old.

B. Description of the Population

The population of the study consisted of 213 sixth grade mathematics students of Stovall Intermediate School located in the Aldine Independent School District. Of these there were 167 I.Q. scores available.

From the 213 students, 108 were randomly selected and assigned to two teachers as the experimental group. The remaining 105 were assigned to the control group and were taught by two other teachers.

C. Development of Achievement Test

Since most sixth grade students have had minimal experiences in geometry, it was decided that this would be the content of the treatment. Upon investigation it was found that no standardized instrument in geometry for the sixth grade was available, consequently, it was necessary for one to be constructed. (See Appendices A & B)

"Skills and Concepts in Geometry", Forms 1 and 2, were developed in the following manner. Since the Aldine Independent School District uses the Addison-Wesley textbook series, the sixth grade textbook was screened for topics in metric and non-metric geometry. Twenty-eight topics were identified (Appendix C). Eighty-four multiple choice items were constructed, three on each topic. No item was taken directly from the text. Each set of items per topic was constructed at three difficulty levels; an attempt was made to provide for equal difficulties at each level across topics.

Two judges, a doctoral candidate and a professor of mathematics education, examined the 84 items. After rating by the independent observers, several items were discarded, and others were revised in their stems and/or alternatives.

The final items were chosen on the basis of their being judged at the middle level of difficulty.

From these items two equivalent forms of the instrument were developed, each consisting of 28 items, one representing each of the 28 subject matter topics. There are four alternatives from which the testee chooses one.

As a result of the method of item construction, content validity was assumed.

In order to collect data for reliability studies, the test was administered to 116 sixth grade students at Friendswood Intermediate School. These children had had similar experiences in mathematics as the students from Aldine. The Kuder Richardson Formula 20 yielded a coefficient of internal consistency of 0.70.

D. General Design

1. Selection and Orientation of Teachers of Experimental Group

The sixth grade of Stovall Intermediate School is departmentalized. Consequently, the selection of teachers for the experimental group was no problem. The school has five mathematics teachers for the sixth grade. One did not wish to participate so the selection of two was made from the four remaining ones by drawing numbers from a box.

These two teachers then participated in five orientation sessions of approximately three hours each. These sessions were concerned with explanation of the project, discussion of the subject matter, and viewing films depicting the contrasting inductive and deductive teaching strategies (see Appendix G). The final session consisted of video-taping and analysis of two micro-teaching efforts of each of the two teachers.

2. Description of the Program

Two groups were established from the 108 students who were randomly selected for the experimental population.

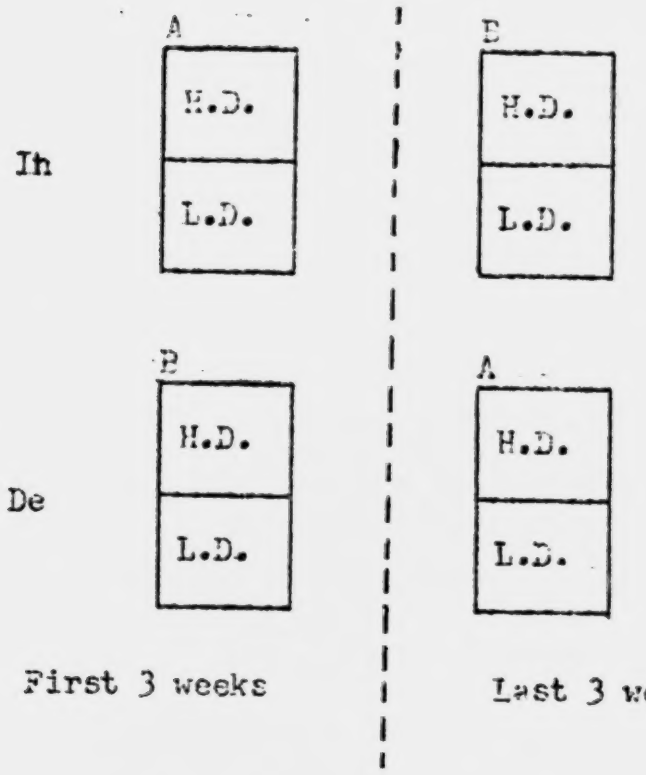
Each of these groups was composed of 54 randomly assigned students, one-half of whom fell above the median and one-half of whom fell below the median scores on the Torrance Test of Creative Thinking.

The experimental procedure involved four instructional sections (classes). One-half of each experimental group was randomly assigned to two of the four instructional sections (see Research Design).

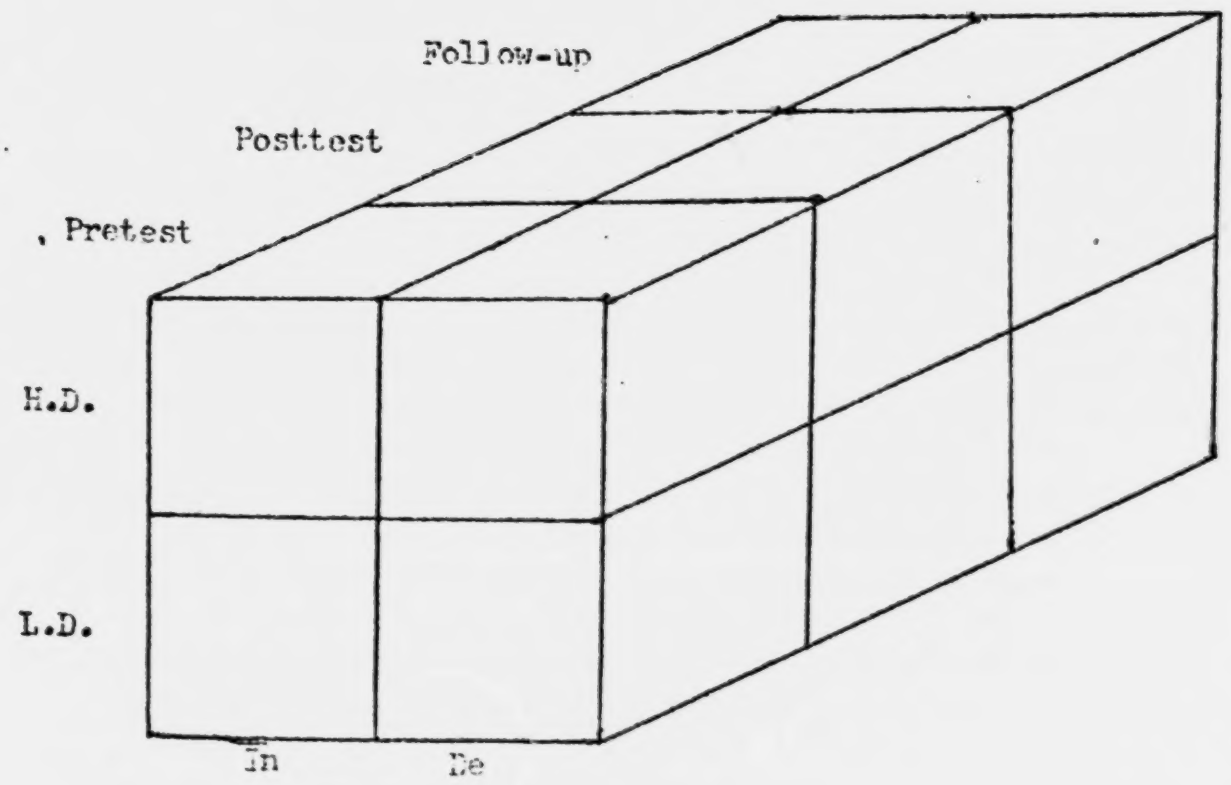
The six week treatment time was separated into two three week periods Teacher A taught two sections using the inductive approach while Teacher B taught the other two sections using the deductive approach. All sections received equivalent treatments. At the end of three weeks, Teacher A taught inductively the two sections taught the previous three weeks by Teacher B, and vice versa.

FIGURE I

RESEARCH DESIGN



A & B Teachers
In Inductive - Guided Discovery Strategy
De Deductive - Reception Strategy
H.D. High Divergent Thinkers
L.D. Low Divergent Thinkers



In order to assure comparability in the experimental sections, a sample of 167 recorded I.Q. scores of the total group was investigated. This investigation revealed that the sections were of comparable ability.

TABLE I

IQ Distributions of Aldine Sixth Graders by Treatment Groups

Group	N	$\overline{X}_{IQ}$	s
Control	77	101.1	11.77
Deductive	43	104.1	12.48
Inductive	47	100.9	9.45

To assure that the teaching strategies were discrete treatments, the classrooms of Teacher A and Teacher B were visited periodically (at least three times per week) by independent observers who used a checklist for analysis. Also, periodically audiotapes were made of the experimental sections. These were analyzed by the principal investigator and several doctoral candidates in Mathematics Education. In addition, four sessions, two for each instructional strategy, were videotaped and analyzed. As a result of these procedures, it was concluded that the treatments were discrete.

3. Collection of Data

The Aldine Independent School District reports the progress of its students each six weeks. Accordingly, in order to best facilitate the study, it was decided that the experimental treatment should begin with the second six week reporting period.

Initially the Torrance Test of Creative Thinking was administered before the beginning of school so that the experimental sections could be assigned. The pre-test for achievement and for attitude was administered prior to the treatment phase, with the post-test in achievement and attitude being administered at the end of the six week treatment period (second six week reporting period). The follow-up tests were administered at the end of the third six week reporting period. In summary, the following data were collected:

a. achievement test scores obtained from pre, post and follow-up tests;

b. scores from Torrance Test of Creative Thinking;

c. pre and post scores from mathematical attitude scale (Appendix F).

Since the sections were taught by two different teachers, the factor of teacher effect was diminished. Also, because both high and low divergent thinkers were assigned to each instructional section, preferences of students were eliminated as a factor.

The 105 students in the control group were randomly assigned to four sections which were taught by two teachers. The control group covered the same material as the experimental group and was taught in the traditional classroom manner.

IV. ANALYSIS AND FINDINGS

For the purpose of analyzing the data collected from this study, it had to be determined if covariance was required. In order to do this, the subjects were separated into three groups, i.e. , control, all inductive, and all deductive. Only those subjects in each group who had both External Variables (I.Q.) and pre-test scored.

At this point a one-way Analysis of Variance was carried out on the External Variable Scores, using a test of means. An examination of Table II reveals that there are no significant differences between groups, therefore, covariance was not required for analysis.

TABLE II

One-way Analysis of Variance on External Variable (IQ) Between Treatment Groups

Source	SS	df	ms	F	P
Total	21,479.30	166	----	----	---
Between	309.31	2	154.66	1.20	NS
Within	21,169.99	164	129.08	----	----

An investigation of Table III reveals that a random sample of only 21 subjects from the control group were used. This situation was created as a result of the type of analysis used, i.e., the analysis necessitated the use of equal numbers within the cells.

TABLE III

Mathematics Achievement Means on Repeated Measures by Treatment Groups

Group	N	Pretest	Posttest	Follow-up
Control	21	9.43	12.95	11.90
Deductive-Low Divergent	21	7.90	12.19	9.90
Deductive High Divergent	21	8.19	13.62	11.05
Inductive Low Divergent	21	9.48	12.24	10.62
Inductive High Divergent	21	8.14	12.86	10.76

Although each of the treatment groups gained in achievement between pre and post testing, Table IV reveals that the treatment had no significant effect on overall achievement between groups. Consequently, null hypotheses H_o1, H_o2, H_o3, H_o8, H_o9 and H_o10 were accepted.

TABLE IV

Analysis of Variance (Two-Factor Mixed Design With Repeated Measures) on Achievement of Five Treatment Groups on Three Measures

Source	SS	df	ms	F	P
Total	4135.19	314	----	----	----
Between Subjects	1714.52	104	----	----	----
Treatments	68.74	4	17.185	1.044	NS
Error (Between)	1645.78	100	16.458	----	----
Within Subject	2420.67	210	----	----	----
Measures	902.61	2	451.305	61.60	.001
Measures x Treatments	52.99	8	6.624	0.904	NS
Error (Within)	1465.07	200	7.326	----	----

Further investigation of Table IV reveals that the subjects achieved significantly over time, which was expected. However, there was no significant difference between the experimental group and the control in retention of subject matter. Thus null hypothesis H_o4 was accepted.

TABLE V

Mathematics Attitude Means on Repeated Measures by Treatment Group (High Scores = Favorable Attitude)

Group	N	Pretest	Posttest
Control	22	77.04	73.14
Deductive - low divergent	22	78.41	77.41
Deductive- high divergent	22	75.50	78.82
Inductive- low divergent	22	81.41	78.14
Inductive- high divergent	22	74.27	73.22

Table V relates the mean scores of each group on the attitude scale for both the pre- test and post test. This scale was a revision of the Aiken Dreger instrument (1961) which employed the Likert scaling procedure. (See Appendix F). The authors reported a test-retest reliability coefficient of 0.94.

Using a scale of 1-5, the range was 20-100, with a neutral score of 60. Thus, the higher the score, the more positive the attitude. An examination of Table V reveals that all five groups had an initial positive attitude, and although the post test results indicated a continuation of this positive attitude, the positive nature was less pronounced.

TABLE VI

Analysis of Variance (Two-Factor Mixed Designed With Repeated Measures) on Attitude of Five Treatment Groups on Two Measures

Source	SS	df	ms	F	P
Total	66,023.71	219	---	---	---
Between Subjects	55,910 .71	109	---	---	---
Treatment	985.56	4	246.39	0.47	NS
Error (Between)	54,925.15	105	523.09	---	---
Within Subjects	10,133 .00	110	---	---	---
Measures	76 .81	1	76.81	0.83	NS
Measures x Treatment	353.20	4	88.30	0.95	NS
Error (Within)	9,682.99	105	92.21	92.21	---

An analysis of the data presented in Table VI indicates that there was no significant attitude change over time interval due to treatment or measures. Furthermore, there appears to be no significant difference in attitude between the five groups . Thus null hypotheses H_o5, H_o6, H_o7, H_o11, H_o12, and H_o13 were accepted.

V. CONCLUSIONS AND RECOMMENDATIONS

A. Conclusions

The present project suggests a number of conclusions about inductive and deductive instructional strategies:

1. There were no significant differences in achievement between the five treatment groups. Although the treatment, either inductive, deductive, or normal classroom procedure (control), occurred for a period of six weeks, neither group achieved significantly more than the other.

2. All groups achieved significantly over time. This indicates that the teachers were highly effective in their teaching efforts, which was expected.

3. Although all groups achieved significantly, there was no significant difference in retention of subject matter between the control group and the experimental group. Indeed, there was no significant difference in retention between any of the five groups.

4. Initially each of the five groups seemed to hold a rather positive attitude toward mathematics. Although this positive attitude persisted during the six week treatment period, with one exception, the positive attitude was less pronounced at the conclusion of the treatment. It was observed that many of the students in the experimental groups seemed to become "tired" of the mathematics toward the end of the treatment period. It is reasonable to assume that this could account for the less positive attitude indicated above. The fact that the treatment material consisted entirely of geometry could also be a contributing factor.

5. Although it was hoped that the treatment would produce a significant positive attitude change, it was found that no significant change was manifest. Furthermore, there appears to have been no significant difference in attitude between any of the five treatment groups. Perhaps this is due to the fact that both groups of teachers were aware of participation in an evaluation research project.

6. Close working relationships were developed among the faculty members of Houston Baptist College, University of Houston faculty and graduate students, and administrators and staff in the Aldine Independent School District. At no time were administrative or logistics problems encountered without a mutual concerted effort to solve whatever problem was at hand.

B. Recommendations

The results of the analysis to date seems to indicate that, although a high significant achievement occurred in all groups, there was no significant difference in achievement or attitude between the groups in this research due to treatment or measures. This is probably due to a treatment period which was too short in duration and participant awareness of participation in research.

The following recommendations are proposed:

1. A similar study with a duration of at least one full academic year be initiated;

2. A study which would include random samples of 4th, 5th, and 6th grade students;

3. A study should be initiated to determine the relationship between creativity and the position of one's surname in the alphabet; (See Appendix J).

Houston Baptist College and the University of Houston are cooperating in preparing a proposal for an Inservice Training Institute in Mathematics education. The proposal is being submitted to the United States Office of Education, Education Personnel Development Division, Teacher Development in Desegregation Schools Branch. The project Director and the principal investigator on this project will direct and evaluate this institute, if funded.

Curriculum instruction for the teachers in mathematics will build upon those teaching strateaies developed and improved during this research. It is hoped that more definitive findings on the efficacy of inductive versus deductive teaching strategies will be developed during the training and evaluation of this proposed institute.

APPENDIX A

SKILLS AND CONCEPTS IN ELEMENTARY GEOMETRY

(Form 1)

Directions for Administering the Test:

Please allow minutes for the pupils to work on this test.

A separate answer sheet is provided. Before starting the test, the teacher should have the pupils fill out the spaces for demographic information required on the answer sheet. Give careful instructions as to how the pupils are to mark their answers.

Materials required by each pupil on this test are as follows:

Pencil
Computation paper
Compass
Ruler
Protractor

Caution pupils to refrain from marking on and puncturing the test booklets.

SKILLS AND CONCEPTS IN ELEMENTARY GEOMETRY (Form 1)

To The Pupil: Do not mark on the test booklet. You may use your compass, ruler, or protractor to perform the measurements required, but do not leave pencil marks or holes in the test booklet. Record your answer choices on the separate sheet provided. Remember that in each question you are to choose the one answer which you believe to be correct, and there is only one correct answer for each question.

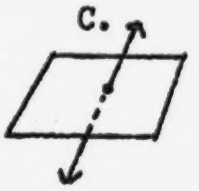
1. One of the statements given below is false. Select the one which you believe to be false.

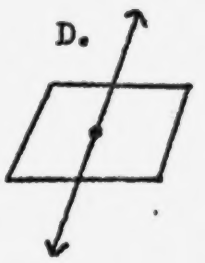
   A. 100 meters is greater than 100 yards.
   B. 5 quarts is less than 5 liters.
   C. 1 kilogram is greater than 2 pounds.
   D. A football field is less than 1 hectometer in length.

2. Which of the following drawings represents a space figure?

A.

B.

C. 

D. 

3. Any cross section of a sphere is

   A. another sphere
   B. a square
   C. a rectangle
   D. a circle

4. The measures of two angles of a triangle are 55° and 70°. What is the measure of the third angle?

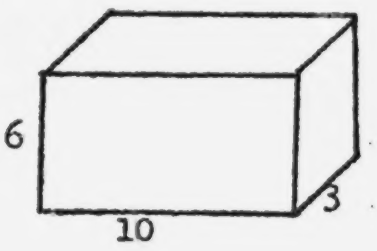
   A. 65° B. 75° C. 45° D. 55°

5. The correct formula to use in finding the volume of a rectangular prism is

   A. $V = l \times w \times h$ B. $A = l \times w$ C. $V = l \times w$ D. $V = Bhl$

6. What is the surface area of the figure drawn below?

   A. 144
   B. 216
   C. 180
   D. 224



7. Find the area of a circle whose radius is 3 inches.

A. 28.62 in. B. 26.82 in. C. 286.2 in. D. 2.86 in.

8. Suppose your teacher had started the construction below on the blackboard but had not finished it. Can you tell what she was trying to do?

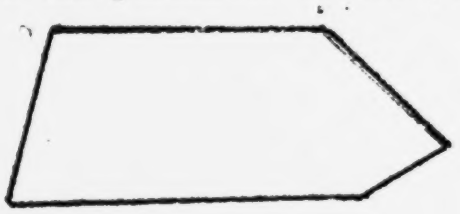
A. Copy the angle
B. Make a triangle
C. Bisect the sides
D. Bisect the angle

9. Use your protractor to find out how many degrees are in the angle below.

A. 60°
B. 50°
C. 75°
D. 55°

10. Use your centimeter ruler to find the perimeter of the polygon below.

A. 10 cm.
B. 12 cm.
C. 14 cm.
D. 15 cm.

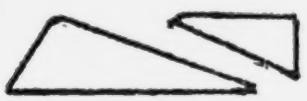


11. Which of the following is a plane figure?

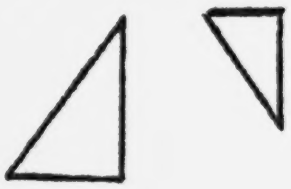
A. A cube
B. Two different planes
C. A face of a cube and an edge not on that face
D. A triangle

12. Which of the following pairs of triangles look congruent?

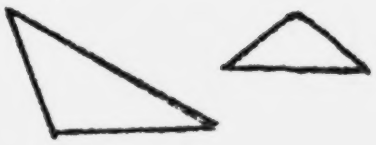
A.



B.



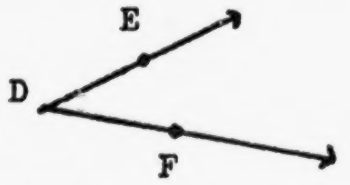
C.



D.

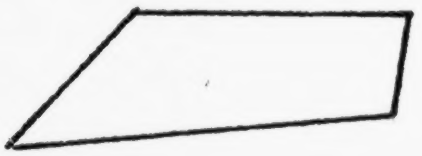
13. Choose the correct name for the figure below.

A. ∠ DEF
B. ∠ FDE
C. ∠ FED
D. ∠ EFD



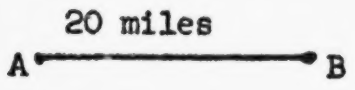
14. Use your protractor to measure the angles in the figure below. Their sum is

A. 340°
B. 360°
C. 370°
D. 180°



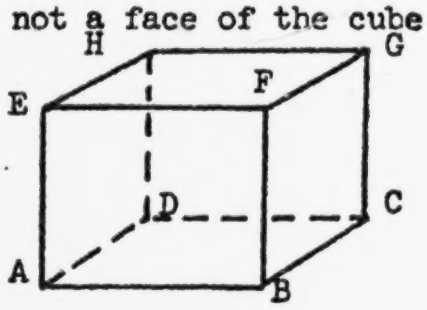
15. $\overline{AB}$ represents a distance of 20 miles. Use your centimeter ruler to find out what scale was used in drawing it.

A. 2 cms. = 20 miles
B. 4 cms. = 20 miles
C. 3 cms. = 20 miles
D. 1 cm. = 20 miles



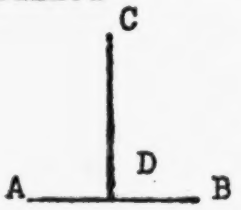
16. Which of the following is not a face of the cube shown below?

A. ACGF
B. EFGH
C. ABCD
D. ADHE



17. $\overline{CD}$ looks to be longer than $\overline{AB}$, but they are really the same length. (Use your compass to check this.) A figure such as this is called

A. a mistake
B. a mirage
C. an optical illusion
D. a construction

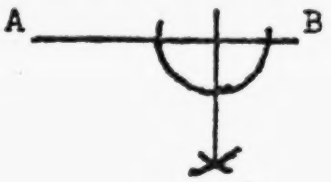


18. A certain rectangular prism (box) has a volume of 27 cubic units. Its length is 3 units and its width is 3 units. We can call it a

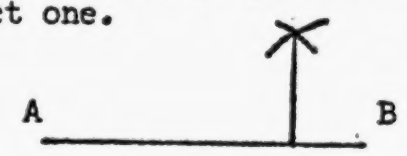
A. square
B. rectangle
C. cylinder
D. cube

19. The constructions below are all attempts to construct the perpendicular bisector of $\overline{AB}$. Only one is correct. Choose the correct one.

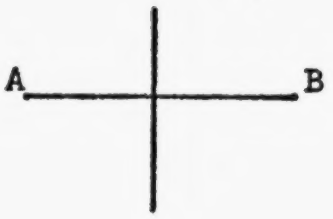
A.



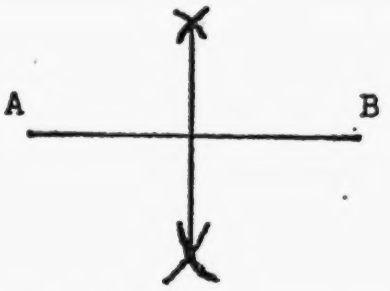
B.



C.

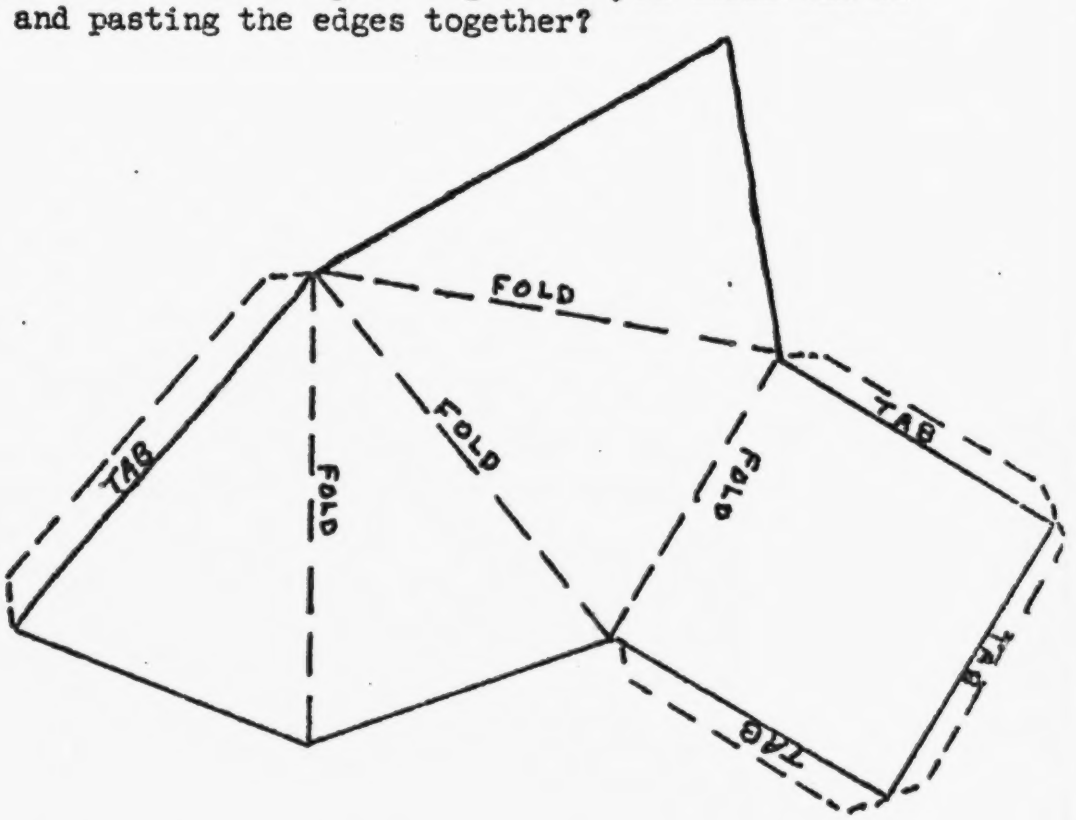


D.



20. Look at the drawing below. What kind of space figure do you think can be formed by cutting it out and pasting the edges together?

A. cube
B. pyramid
C. cylinder
D. cone



21. Which set of points is on the ray containing Q and end-point P?

A. {Q,B,P}
B. {Q,P,A}
C. {R,P,Q}
D. {R,A,P}

22. Name the figure formed by all the points in a plane which are the same distance from a particular point, such as A below.

A. square
B. circle
C. triangle
D. pyramid

.A

23. The two shortest sides of a right triangle have lengths of 6 inches and 8 inches. What is the length of the hypotenuse?

A. 100 inches
B. 14 inches
C. 7 inches
D. 10 inches

24. If $\overline{AB} \cong \overline{CD}$, then choose the statement below which is true.

A. the lines $\overleftrightarrow{AB}$ and $\overleftrightarrow{CD}$ have equal lengths
B. the segments $\overline{AB}$ and $\overline{CD}$ must be the same segment
C. the rays $\overrightarrow{AB}$ and $\overrightarrow{CD}$ go in the same direction
D. the end-points of $\overline{AB}$ are exactly as far apart as the end-points of $\overline{CD}$

25. Houston and Dallas are 250 miles apart by the shortest route. At a scale of 1 inch per 100 miles, find the length of the shortest segment that separates Houston and Dallas on a map.

A. 2.5 inches
B. 0.4 inches
C. 3.0 inches
D. 0.7 inches

26. Two angles are congruent if

A. their vertices are placed on top of each other
B. their rays have equal lengths
C. they belong to the same triangle
D. Corresponding points on their rays are equally far apart

27. The meaning of the prefix "kilo" in the metric system is

A. one thousandth
B. one thousand
C. one hundred
D. one hundredth

28. A line which is perpendicular to one of two parallel lines is

A. parallel to the other line
B. perpendicular to the other line
C. congruent to the other line
D. equal to the other line

APPENDIX B

SKILLS AND CONCEPTS IN ELEMENTARY GEOMETRY

(Form 2)

Directions for Administering the Test:

Please allow as much time as pupils need to complete this test.

A separate answer sheet is provided. Before starting the test, the teacher should have the pupils fill out the spaces for demographic information required on the answer sheet. Give careful instructions as to how the pupils are to mark their answers.

Materials required by each pupil on this test are as follows:

Pencil
Computation paper
Compass
Ruler (marked with centimeter scale)
Protractor

Caution pupils to refrain from marking on and puncturing the test booklets.

SKILLS AND CONCEPTS IN ELEMENTARY GEOMETRY (Form 2)

To the Pupil: Do not mark on the test booklet. You may use your compass, ruler, or protractor to perform the measurements required, but do not leave pencil marks or holes in the test booklet. Record your answer choices on the separate sheet provided. Remember that in each question you are to choose the one answer which you believe to be correct, and there is only one correct answer for each question.

1. One of the statements given below is false. Select the one which you believe to be false.

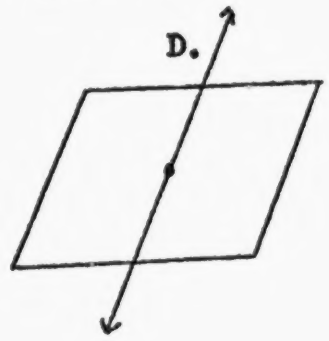
   A. 100 meters is greater than 100 yards.
   B. 3 quarts is less than 3 liters.
   C. 1 kilogram is greater than 2 pounds.
   D. A football field is less than 1 hectometer in length.

2. Which of the following drawings represents a space figure?

A.

B.

C.

D. 

3. Any cross section of a sphere is

   A. another sphere
   B. a square
   C. a rectangle
   D. a circle

4. The measures of two angles of a triangle are 65° and 70°. What is the measure of the third angle?

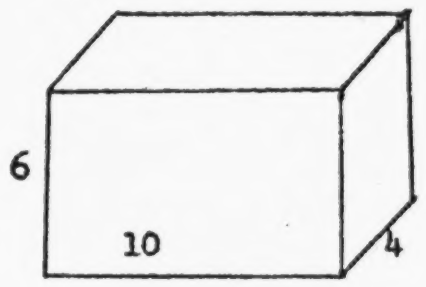
   A. 65° B. 75° C. 55° D. 45°

5. The correct formula to use in finding the volume of a cube is

   A. $V = l \times w \times h$ B. $V = l \times w$ C. $V = w \times h$ D. $V = Bhl$

6. What is the surface area of the figure drawn below?

   A. 144
   B. 248
   C. 180
   D. 224



7. Find the area of a circle whose radius is 6 inches.

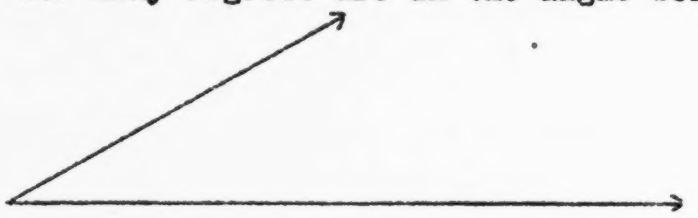
A. 113.04 sq. in. B. 131.04 sq. in. C. 11.30 sq. in. D. 1130.4 sq. in.

8. Suppose your teacher had started the construction below on the blackboard but had not finished it. Can you tell what she was trying to do?

A. Bisect the angle
B. Make a triangle
C. Bisect the sides
D. Copy the angle

9. Use your protractor to find out how many degrees are in the angle below.

A. 30°
B. 50°
C. 25°
D. 40°



10. Use your centimeter ruler to find the perimeter of the polygon below.

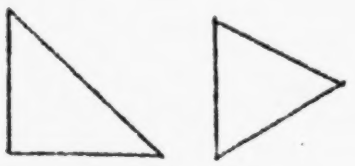
A. 12 cm.
B. 16 cm.
C. 14 cm.
D. 15 cm.

11. Which of the following is a plane figure?

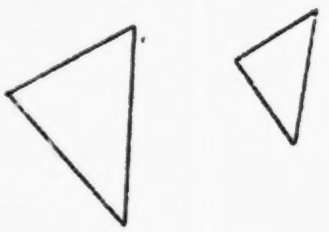
A. A cube
B. Two different planes
C. A face of a cube and an edge not on that face
D. A square

12. Which of the following pairs of triangles look congruent?

A.



B.

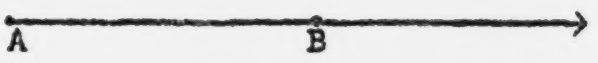


C.

D.

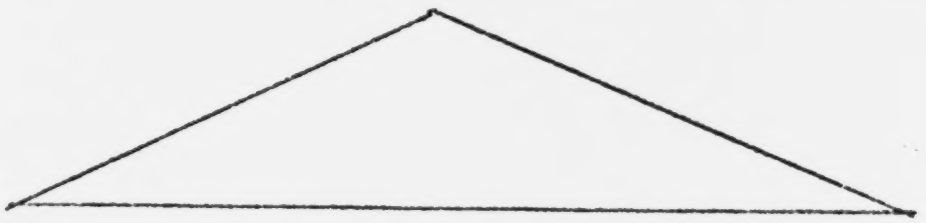
13. Choose the correct name for the figure below.

A. $\overrightarrow{BA}$
B. $\overline{AB}$
C. $\overleftrightarrow{AB}$
D. $\overleftarrow{AB}$



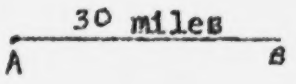
14. Use your protractor to measure the angles in the figure below. Their sum is

A. 360°
B. 180°
C. 150°
D. 225°



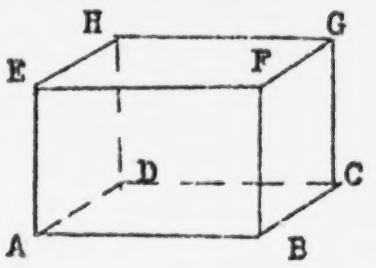
15. $\overline{AB}$ represents a distance of 30 miles. Use your centimeter ruler to find out what scale was used in drawing it.

A. 1 cm. = 15 miles
B. 1 cm. = 7.5 miles
C. 1 cm. = 10 miles
D. 1 cm. = 30 miles



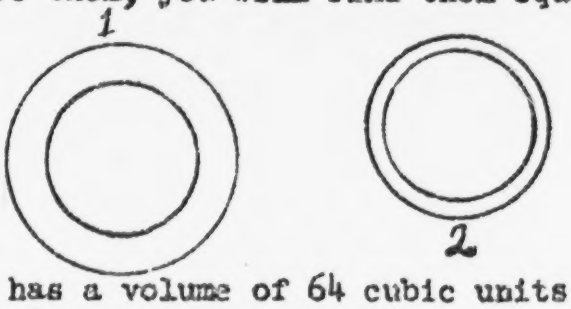
16. Which of the following is not a face of the cube shown below?

A. DCGF
B. EFGH
C. ABCD
D. ADHE



17. In the figures below, the inner circle in figure 2 appears larger than the one in figure 1. If you measure them, you will find them equal. This type of event is called

A. a mistake
B. a mirage
C. an optical illusion
D. a construction

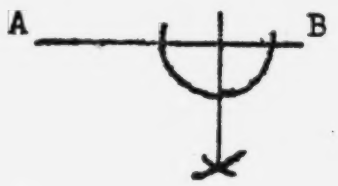


18. A certain rectangular prism (box) has a volume of 64 cubic units. Its length is 4 units and its width is 4 units. We can call it a

A. square
B. rectangle
C. cylinder
D. cube

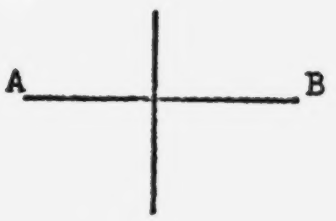
19. The constructions below are all attempts to construct the perpendicular bisector of $\overline{AB}$. Only one is correct. Choose the correct one.

A.

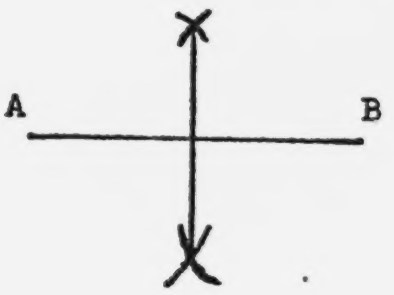


B.

C.

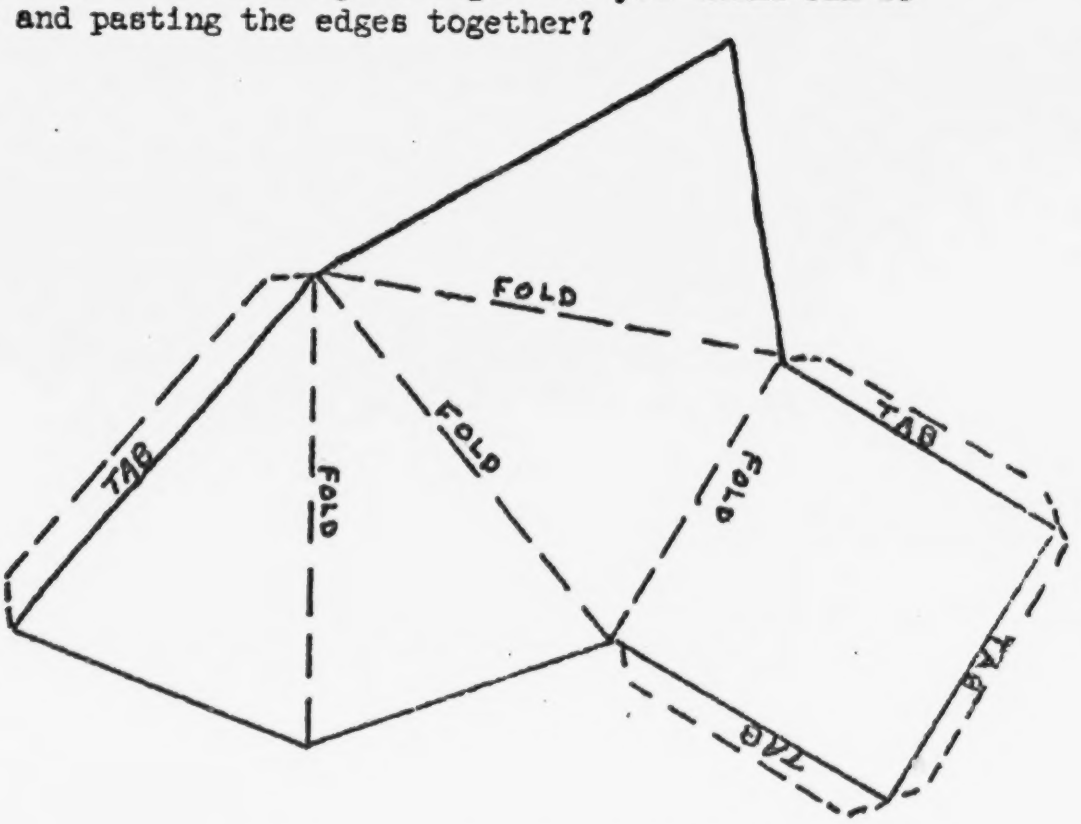


D.



20. Look at the drawing below. What kind of space figure do you think can be formed by cutting it out and pasting the edges together?

A. cube
B. pyramid
C. cylinder
D. cone



21. Which set of points is on the ray containing A and end-point P?

A. {R,A,P}
B. {Q,P,A}
C. {R,P,Q}
D. {Q,B,P}

22. Name the figure formed by all the points in a plane which are the same distance from a particular point, such as P below.

P

A. square
B. circle
C. triangle
D. pyramid

23. The two shortest sides of a right triangle have lengths of 3 inches and 4 inches. What is the length of the hypotenuse?

A. 25 inches
B. 14 inches
C. 7 inches
D. 5 inches

24. If $\overline{EF} \cong \overline{GH}$, then choose the statement below which is true.

A. the lines $\overleftrightarrow{EF}$ and $\overleftrightarrow{GH}$ have equal lengths
B. the segments $\overline{EF}$ and $\overline{GH}$ must be the same segment
C. the rays $\overrightarrow{EF}$ and $\overrightarrow{GH}$ go in the same direction
D. the end-points of $\overline{EF}$ are exactly as far apart as the end-points of $\overline{GH}$

25. Houston and Dallas are 250 miles apart by the shortest route. At a scale of 1 inch per 50 miles, find the length of the shortest segment that separates Houston and Dallas on a map.

A. 5 inches
B. 0.2 inches
C. 6 inches
D. 1.4 inches

26. Two angles are congruent if

A. their vertices are placed on top of each other
B. their rays have equal lengths
C. they belong to the same triangle
D. corresponding points on their rays are equally far apart

27. The meaning of the prefix "centi" in the metric system is

A. one thousandth
B. one hundredth
C. one hundred
D. one thousand

28. A line which is parallel to one of two parallel lines is

A. perpendicular to the other line
B. parallel to the other line
C. congruent to the other line
D. equal to the other line

APPENDIX C

Aldine Teaching Strategies Mathematics Project

Six Weeks' Subject Matter Outline

Geometry -- Sixth Grade Level

Note: Topics are based on the material found in Elementary School Mathematics Book 6 by Eicholz (et al.), Addison Wesley Publishing Co., 1964 Edition. Supplementary materials for most topics are recommended. Page numbers listed in the outline are from the textbook cited above.

Lesson No.	Topic	Pages
1	Pretest on Geometry Competence	
2	Sets of Points	188-189
3	Lines, Rays, Segments	190-191
4	Angles, Triangles	192-193
5	Congruent Segments	194
6	Congruent Angles	195
7	Congruent Triangles	196-197
8	Copying and Bisecting Angles	198
9	Constructing Perpendicular Lines	199
10	Constructing Triangles	200
11	Copying Triangles	201
12	Parallel Lines Defined and Constructed	202-203
13	More About Parallels	204-205
14	Optical Illusions	206-207
15	Planes and Solids	208-209
16	The Cube	210
17	Cross Sections	211
18	Constructing Space Models	212
19	Review	213
20	Length and Perimeter	20-21
21	Area and Surfaces	42-43

Lesson No.	Topic	Pages
22	Volume	84-85
23	Angle Measure	100-101
24	Computing with Angle Measures	116-117
25	Scale Drawings	144-145
26	Pythagorean Theorem	226-227
27	Metric System	262-263
28	Circumference of a Circle	282-283
29	Area of a Circle	296-297
30	Posttest on Geometry Competence	

APPENDIX D

Inductive Strategy - Lesson 16

Topic: The Cube

Generalization: Definition and properties of a cube

Materials: Sugar cubes, or some other small cube which can be given to each student.

Activity 1.

Give each student a cube. Ask them to describe the object by giving some of its properties. Expect answers such as"square sides" (when you repeat, call it "square face"), "eight corners" (when you repeat, call it "eight vertices), "twelve sides" (when you repeat, call is "twelve edges"). Ask the students if there is a particular name for the geometric figure formed by this object. Tell the students that they may eat the cubes if they desire.

Activity 2.

Ask if anyone knows how to draw the figure for the object which they have been discussing. Let the students attempt to draw the figures on the board. If some student draws a fairly good figure, ask them how it should be labeled. Continue to discuss labeling until all of the students are satisfied that it is necessary and sufficient to label each of the vertices.

Activity 3.

Divide the students into two groups for quiz competition. Draw a cube in the center of the board and label it exactly like the cube given on page 210 of the text. Send two students (one from each team) to the board. Have them use the blank space on each side of the figure to write their answers to the questions. Ask the questions given on page 210 of the text. Allow the student who gets the correct answer first to make a tally mark at the top of the board. (Makes up a few questions. There are not enough in the text.)

APPENDIX E

Aldine Mathematics Teaching Strategies Project

Deductive-Reception Strategy

Lesson Plan 16 (Addison-Wesley, p. 210)

1. Generalization: Pupils are to be able to recognize a cube and identify its faces, edges, and vertices.
2. Materials: Routine pupil supplier; models of cubes.
3. Activities;
   a. Draw a cube on the blackboard. Label its parts.
   b. State to the pupils that a cube has 6 faces. Name one of them by the letters of the vertices. Tell them that each face is a square region.
   c. Ask the pupils to identify the other five faces of the cube. Check their answers.
   d. Explain that a cube has 8 vertices. Name one of them. State that when three planes intersect, a point is formed. Show them that when three faces come together, a vertex is formed.
   e. Ask the pupils to identify the other 7 vertices. Check their answer for understanding.
   f. State that the edge of a cube is the line that is formed when two faces intersect. Show them an edge and name it.
   g. Ask the pupils to identify all other edges of the cube. Check their answers.
   h. State that the opposite edges of a cube are parallel. Choose one edge and name the other edges which are paralled to it.
   i. Choose 3 other edges and ask the pupils to name all edges paralle to each.
   j. Ask the names of four vertices which do not all lie in one plane.
   k. Review what has been learned about the parts of a cube.

Appendix F

REVISED MATH ATTITUDE SCALE

Directions: Each of the sentences on this paper tells a feeling which people have toward arithmetic. You are to show by circling, what the sentence says as to what you feel when you do math. The five choices are: Really Dislike, Dislike, Do Not Know, Like, and Really Like. You are to circle the one choice which best tells how closely you like or dislike the feeling given in each sentence AS YOU FEEL ABOUT IT.

1. I am always under a terrible strain in a math class.
2. I do not like math, and it scares me to have to take it.
3. Math is very interesting to me, and I like the subject.
4. Math keeps me interested and is fun.
5. Math makes me feel good, and at the same time it is fun.
6. My mind quits working, and I cannot think clearly when working math.
7. I feel unhappy when I try Math.
8. Math makes me feel sad, unhappy, and in a bad mood.
9. The feeling that I have toward math is a good feeling.
10. Math makes me feel as though I'm lost in a bunch of numbers and I cannot find my way out.
11. Math is something which I like a lot.
12. When I hear the word math, I do not like it.
13. I begin math with a bad feeling, which comes from being afraid of making children laugh.
14. I really like math.
15. Math is a subject in school which I have always liked to study.
16. It makes me scared to even think about having to do arithmetic problems.
17. I do not like math, and it is the subject which I am most afraid.
18. I feel good in a math class, better than in any other class.
19. I feel good and comfortable in math, and I like it very much.
20. I feel good about math; it is fun.

APPENDIX G

ROLE OF THE TEACHER IN EACH STRATEGY

Inductive

1. Allow children to express their partial learning.
2. Allow children to pursue through questioning.
3. Allow children to express closure at whatever level.
4. Avoid giving next logical step.
5. Ask questions after students have exhausted theirs.
6. Do not require final verbalizations of principles.
7. It is important to comprehend that what is being measured on this experiment is not excellence in teaching per se, but whether or not one strategy of teaching is superior to another with given children. Thus, teaching until the whole group or a given percentage of the group understands is in conflict with measuring the effect of the strategy.

Deductive

1. Use a well worked out logical pattern (as in sample lesson).
2. Point out logical steps in order.
3. Allow children to ask questions.
4. Answer questions and make statements; do not formulate questions.
5. Allow children to express their partial learning.
6. Allow children to express closure at whatever level.
7. It is important to comprehend that what is being measured in this experiment is not excellence in teaching per se, but whether or not one strategy of teaching is superior to another with given children. Thus, teaching until the whole group or a given percentage of the group understands is in conflict with measuring the effect of the strategy.

APPENDIX H

SKILLS AND CONCEPTS IN ELEMENTARY GEOMETRY

Answer Sheet

Pupil _____ School _____
Last Name First Name M.I.

Teacher _____ Grade Level _____ Period _____

Testing Date: ____/____/____
Mo. Day Yr.

Birth Date: ____/____/____
Mo. Day Yr.

Test Score

Instructions: Do not mark on the test booklet. After deciding which letter you have chosen as being correct for each question, shade in that letter as shown:

(A) ● (C) (D)

This indicates that you have chosen "B" as the correct answer. If you change your mind later and wish to change your answer, erase your first mark completely and shade in your second choice.

1. (A) (B) (C) (D)
2. (A) (B) (C) (D)
3. (A) (B) (C) (D)
4. (A) (B) (C) (D)
5. (A) (B) (C) (D)
6. (A) (B) (C) (D)
7. (A) (B) (C) (D)
8. (A) (B) (C) (D)
9. (A) (B) (C) (D)
10. (A) (B) (C) (D)
11. (A) (B) (C) (D)
12. (A) (B) (C) (D)
13. (A) (B) (C) (D)
14. (A) (B) (C) (D)
15. (A) (B) (C) (D)
16. (A) (B) (C) (D)
17. (A) (B) (C) (D)
18. (A) (B) (C) (D)
19. (A) (B) (C) (D)
20. (A) (B) (C) (D)
21. (A) (B) (C) (D)
22. (A) (B) (C) (D)
23. (A) (B) (C) (D)
24. (A) (B) (C) (D)
25. (A) (B) (C) (D)
26. (A) (B) (C) (D)
27. (A) (B) (C) (D)
28. (A) (B) (C) (D)

APPENDIX I

NAME_____

Answer Sheet

Please write your name in the upper right hand corner:

1.	Really Dislike	Dislike	Do Not Know	Like	Really Like
2.	Really Dislike	Dislike	Do Not Know	Like	Really Like
3.	Really Dislike	Dislike	Do Not Know	Like	Really Like
4.	Really Dislike	Dislike	Do Not Know	Like	Really Like
5.	Really Dislike	Dislike	Do Not Know	Like	Really Like
6.	Really Dislike	Dislike	Do Not Know	Like	Really Like
7.	Really Dislike	Dislike	Do Not Know	Like	Really Like
8.	Really Dislike	Dislike	Do Not Know	Like	Really Like
9.	Really Dislike	Dislike	Do Not Know	Like	Really Like
10.	Really Dislike	Dislike	Do Not Know	Like	Really Like
11.	Really Dislike	Dislike	Do Not Know	Like	Really Like
12.	Really Dislike	Dislike	Do Not Know	Like	Really Like
13.	Really Dislike	Dislike	Do Not Know	Like	Really Like
14.	Really Dislike	Dislike	Do Not Know	Like	Really Like
15.	Really Dislike	Dislike	Do Not Know	Like	Really Like
16.	Really Dislike	Dislike	Do Not Know	Like	Really Like
17.	Really Dislike	Dislike	Do Not Know	Like	Really Like
18.	Really Dislike	Dislike	Do Not Know	Like	Really Like
19.	Really Dislike	Dislike	Do Not Know	Like	Really Like
20.	Really Dislike	Dislike	Do Not Know	Like	Really Like

APPENDIX J

CREATIVITY AND ATTITUDES TOWARD MATHEMATICS

By

William B. Crittenden

A Preliminary Report

Aldine Mathematics Teaching Strategies Project

University of Houston
Houston Baptist College
Aldine Independent School District

November 1969

This project is supported by the U. S. Office of Education, Grant # OEG-509 and sponsored by Houston Baptist College.

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CREATIVITY AND ATTITUDE TOWARD MATHEMATICS

I. Background

Getzels and Jackson (1962) found that creative students were nonconforming and often disruptive of classroom routine and irritating to their teachers. Ausubel predicts that there will be a negative relationship between creativity and school grades. His prediction was supported by the findings of Edwards and Tyler (1965), who compared ninth-grade pupils in the upper third of their distribution in both scholastic aptitude and creativity with those who ranked high in scholastic aptitude alone.[1] Carrying this chain of logic one more step, is it not possible that the attitudes toward academic subjects possessed by divergent pupils would begin to sour as they progress through the grades?

Long, Henderson, and Zillar (1965) found that highly-original fifth and sixth grade children were alienated from authority figures, lower in self-esteem, and described themselves as being unhappy.[2] Torrance discovered that in sixth grade there was a tendency for groups to organize to control the most creative member. Control techniques included open aggression, hostility, criticism, rejection, and indif-

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[1]David P. Ausubel, Educational Psychology: A Cognitive View (New York: Holt, Rinehart and Winston, Inc., 1968), p. 557.

[2]E. Paul Torrance, Torrance Tests of Creative Thinking, Norms-Technical Manual (Princeton: Personnel Press, Inc., 1966), p. 47.

ference. Counteraction by creative members toward the controlling group included counter-aggressiveness, indomitable persistence, apparent ignoring of criticism, clowning silence and apathy, inconsistent performance, and filling in gaps when others faltered.[3]

Wodtke (1963) used a technique of observing pupil behaviors and correlating them with creativity. He concluded that some creative children become classroom behavior problems, and that more creative children have been more severely suppressed than less creative children because of their unusual ideas.[4] The treatment received by divergent thinkers from teachers and fellow pupils would give reason to expect a reaction on their part toward their studies. The traditional methods of teaching mathematics by rote and drill would seem to make that subject an especially inviting target for the disaffection of such pupils.

Riedesel comments that in the past methods used to teach mathematics were of a variety that did little to encourage creative thinking. In fact, they may well have discouraged most high-level thought processes.[5] Torrance contends that children who are taught in such a way as to

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[3] Ibid., pp. 27-28.

[4] Ibid., p. 42.

[5] C. Alan Riedesel, Guiding Discovery in Elementary School Mathematics (New York: Appleton-Century-Crofts, 1967), p. 491.

discourage creative ways of learning will develop differently from those who are permitted to learn in creative ways.[6] He also posits that creative thinking abilities are not static or fixed, but that they can be developed through educational experiences. Children who score high on measures of creative thinking abilities prefer to learn in creative ways--by experimentation, manipulation, and inquiry, rather than by authority.[7]

Aiken (1963) made a correlational study between attitudes toward mathematics and personality variables.[8] His sample consisted of 160 women college students, and his instruments were the Revised Mathematics Attitude Scale and the Sixteen Factor Personality Questionnaire of the California Psychological Inventory. Using Cattell's cluster technique for scaling, he produced characteristics called "extroversion", "conscientiousness", and "self-control" that were associated with positive attitudes toward mathematics. Given a highly creative pupil in sixth grade, who has been subjected to the kinds of situations described

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[6]Torrance, op. cit., p. 17.

[7]Ibid., p. 4.

[8]L. R. Aiken, Jr., "Personality Correlates of Attitude Toward Mathematics," Journal of Educational Research, 56 (May-June, 1963), pp. 476-480.

above, is it likely that he would retain a positive attitude toward mathematics, ingredients of which include those factors found by Aiken?

One of the most difficult problems faced by educators is that of encouraging creativity and individualism without seriously endangering the valid and essential requirements of the group. Elizabeth Simpson has analyzed the dilemma as being separation, in which the individual must be himself at all costs, and recognition, in which strength drawn from the group has as its price the abandonment of individuation. "In the integrative process, the group makes man less himself and more everyone."[9]

Education's most virulent attacks seem to be centered about the cry that schools destroy creativity. Witness the following excerpt from a now-defunct but long-time popular national journal in the recent past:

> Almost every child on the first day he sets foot in a school building is smarter, more curious, less afraid of what he doesn't know, better at finding and figuring things out, more confident, resourceful, persistent and independent than he ever will be again in his schooling... [He is taught] that learning is separate from living. [He learns that he is] a blank sheet for other people to write on... He learns that to be wrong, uncertain, confused is a crime. Right Answers are what the school wants... He learns to

---

[9]Elizabeth L. Simpson, "The Individual in the Group," Phi Delta Kappan, L, No. 6 (February, 1969), pp. 322-324.

> be lazy. ... It is a rare child who can come through his schooling with much left of his curiosity, his independence, or his sense of his own dignity, competence and worth.[10]

These are strong words, and every educator must have some reaction to them. There is enough truth in what Holt says that makes the task of refutation difficult. Nevertheless, as is the case with most generalized condemnations, the innocent are being punished along with the guilty. There are pupils in some American schools who are creative, who are being taught in ways which do not result in turning attitudes toward school subjects sour, and where individuality is preserved in the midst of the group. These findings were evident in the results of a study made of 103 sixth grade pupils of the Aldine Independent School District, near Houston, Texas.

II. The Sample and Data Collection

A. The Sample

Four heterogeneously-grouped sixth grade sections containing 108 pupils were selected from the Aldine Independent School District. The selection was made in keeping with the purposes of a teaching strategies research project sponsored by the University of Houston and funded by

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[10]John Holt, "School Is Bad For Children," Saturday Evening Post, 242, 73 (February, 1969).

the U. S. Office of Education. There were 57 males and 51 females in the sample.

Aldine has a student population of approximately 20,000 and is located on the north of Houston, adjacent to the city. It can be characterized as being representative of many American School districts, having both rural and urban aspects, and its economic index runs the gamut from the poverty stricken to the affluent. Three ethnic groups inhabit the area and attend the schools on the integrated basis.

B. Creativity Scale

The Figural Form A of the Torrance Tests of Creative Thinking was administered to all 108 pupils, with the purpose of identifying high and low divergent thinkers. (There are three activities, or subtest, on the Figural Form. They are Picture Contruction, Incomplete Figures, and Parallel Lines activities. Four constructions of creativity are measured. They are Fluency, Flexibility, Originality, and Elaboration.)

The usual treatment of data collected on these tests is to keep the four construct measurements separate, but for the purpose of identification in the project, it was decided to use a composite, or summation,

score. Other researchers have used this technique, such as Clark (1964), who found a low but significant positive relationship between preference for open-structure learning experiences and high composite creativity scores.[11] Although Torrance himself does not generally recommend the use of summed construct scores, he states, "... such a score does seem to give a rather stable index of the total amount of creative energy a person has available or is willing to use. Reliabilities are generally higher for such total scores than for separate composite scores..."[12]

Reliability data given for the Figural Form A was based on a group of 118 children in St. Croix, Wisconsin, grades 4-6. Test-retest coefficients were as follows: Fluency, 0.71; Flexibility, 0.73; Originality, 0.85; and Elaboration, 0.83.[13] Content validity is inferred from the author's assertion that "... a consistent and deliberate effort has been made to base the test stimuli, the test tasks, instructions, and scoring procedures on the best theory and research now available."[14]

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[11]Torrance, op. cit., p. 41.

[12]Ibid., p. 72.

[13]Ibid., p. 21.

[14]Ibid., p. 24.

The scoring of the Torrance tests has been criticized by some as being unreliable. Evidence quoted by him seems to satisfactorily answer the criticism. Nevertheless, in an attempt to provide for consistency in the scoring of tests on the project, three graduate assistants, after training, separated the scoring duties as follows: One scored all 103 tests on all three activities for Originality; another scored for Flexibility; and the third scored for Fluency and Elaboration. Spot cross-checking by others was done, and results were found to be comparable.

Table I (Page 9) shows the frequency distribution of composite scores of creativity. The median score was 97; the range of scores was from 41 to 177. It can be noted that the distribution is positively skewed.

C. Mathematics Attitude Scale

The Revised Mathematics Attitude Scale is a revision of one developed by Aiken and Dreger in 1961 for use with college students. The scale and its substantiating information were taken from Shaw and Wright.[15] The 20 Likert-type items were developed from paragraphs written by 310 college students. A further revision was made to adapt the scale for use

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[15] Marvin E. Shaw and Jack M. Wright, Scales for the Measurement of Attitudes (New York: McGraw-Hill Book Company, 1967), pp. 242-244.

by elementary-aged children. Words more suitable for that level were substituted for those terms not likely to be understood by children. Ten of the 20 items connote positive attitudes, and ten connote negative attitudes.

TABLE I. FREQUENCY DISTRIBUTION OF ALDINE SIXTH GRADE PUPILS' COMPOSITE SCORES ON TORRANCE TEST OF CREATIVE THINKING VERBAL FORM A'

Class	Frequency
170-179	3
160-169	0
150-159	1
140-149	3
130-139	3
120-129	7
110-119	15
100-109	18
90-99	17
80-89	10
70-79	12
60-69	9
50-59	8
40-49	2

Response to each item was made by choosing one of five alternatives: really dislike, dislike, do not know, like, and really like. The response alternatives were weighted from 5 (for really like) to 1 (for really dislike). The weights were reversed for negative items. Each subject's total score was the summation of the weighted alternatives chosen by him. Hence, high scores reflected positive attitudes toward mathematics, and low scores reflected negative attitudes. The theoretical range was from a low score of 20 to a high score of 100, with the median at 60.5.

Reliability of the scale is based on information furnished by Aiken and Dreger for the original scale. Test-retest procedures yielded a coefficient of 0.94. For validity, scores were found to be significantly related to final course grades of 67 females, but not to the grades of 60 males. Discriminant validity was noted by the results of a test of independence between attitude scale scores and scores on four items designed to measure attitudes toward academic subjects in general.

A total of 103 pupils were given the attitude scale. Results included the range of from 35 to 100, with the median at 80.0. Only 19 of the pupils scored below the theoretical median of 60.5, or in what might be termed that portion of the continuum which contains pupils with negative attitudes toward mathematics. As can be seen from the data contained in Table II, 15 youngsters scored the maximum of 100 or very near

it. The skewed condition of the distribution may indicate that some children sensed which answers were "desirable" and responded accordingly.

TABLE II. FREQUENCY DISTRIBUTION OF ALDINE SIXTH GRADE PUPILS' SCORES ON REVISED MATHEMATICS ATTITUDE SCALE

Class	Frequency
96-100	15
91-95	8
86-90	13
81-85	14
76-80	11
71-75	5
66-70	11
61-65	6
56-60	5
51-55	6
46-50	4
41-45	2
36-40	2
31-35	1

N = 103

D. Other Data Pertinent to the Problem

Intelligence quotients for 87 of the 108 pupils were obtained from the cumulative record files. No intelligence tests were administered to the sample during this project. The IQ scores ranged from 83 to 136, with a median of 102.4 (Table III). The distribution was positively skewed.

TABLE III. FREQUENCY DISTRIBUTION OF ALDINE SIXTH GRADE PUPILS' IQ SCORES

Class	Frequency
136-140	1
131-135	0
126-130	0
121-125	3
116-120	6
111-115	10
106-110	13
101-105	16
96-100	14
91-95	9
86-90	13
81-85	2

N = 87

it. The skewed condition of the distribution may indicate that some children sensed which answers were "desirable" and responded accordingly.

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Class	Frequency
96-100	15
91-95	8
86-90	13
81-85	14
76-80	11
71-75	5
66-70	11
61-65	6
56-60	5
51-55	6
46-50	4
41-45	2
36-40	2
31-35	1

N = 103

D. Other Data Pertinent to the Problem

Intelligence quotients for 87 of the 108 pupils were obtained from the cumulative record files. No intelligence tests were administered to the sample during this project. The IQ scores ranged from 83 to 136, with a median of 102.4 (Table III). The distribution was positively skewed.

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Class	Frequency
136-140	1
131-135	0
126-130	0
121-125	3
116-120	6
111-115	10
106-110	13
101-105	16
96-100	14
91-95	9
86-90	13
81-85	2

N = 87

Scanning of the distribution of creativity scores and pupils' names led to a rather curious phenomenon and might suggest a fruitful area for further research. It appeared that there was a preponderance of high divergence scores in the upper portion of the alphabet. Therefore, it was decided to examine the variable "position in the alphabet" in relation to the creativity scores. Pupils were assigned numbers according to the first letter of their surnames, as "1" for A, "2" for B, etc.

III. Findings

A. Creativity and Attitude Toward Mathematics

Table IV shows the distribution of scores when controlled for creativity and mathematics attitude. The medians in both cases were used to

TABLE IV. COMPOSITE CREATIVITY OF ALDINE SIXTH GRADE PUPILS CONTROLLED BY ATTITUDE TOWARD MATHEMATICS

	Attitude Toward Mathematics		
Creativity	Positive(≥ 80.0)	Negative(< 80.0)	Total
High(Above 97)	22 (42%)	29 (57%)	51
Low(Below 97)	30 (58%)	22 (43%)	52
Total	52 (100%)	51 (100%)	103

$X^2 = 2.12$ (Non-significant at 5% level)

divide the categories. High creativity was ascribed to those pupils whose composite scores were greater than 97.0. Positive attitudes toward mathematics were ascribed to pupils whose scale scores were greater than or equal to 80.0. The chi square statistic of proportionality between cells was computed and yielded no significant difference. The Pearson product-moment correlation coefficient was computed between the two sets of scores, yielding a value of 0.07, which is also not significantly different from chance variation.

B. Creativity and IQ

Ausubel has listed a number of studies on the relationship between creativity and IQ scores and summarizes by stating that only "moderate" correlation (r = 0.25--0.30) exists between them.[16] Torrance does not seem to feel the "true" relationship is even of that degree. "Highly creative children do not show up better than they do on intelligence scales," he writes, "because their ideas do not conform to standardized dimensions and behavioral norms on which responses are evaluated."[17]

Table V presents the distribution of categories controlling composite creativity by intelligence divided at the medians of the groups.

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[16] Ausubel, op. cit., p. 555.

[17] Torrance, op. cit., p. 26.

The chi square value was too low for significant difference from chance at the .05 level. This result, combined with a Pearson's r of 0.10 between the sets of variables, tends to support previous findings of little or no relationship between the two personality factors.

TABLE V. COMPOSITE CREATIVITY OF ALDINE SIXTH GRADE PUPILS CONTROLLED BY INTELLIGENCE

	IQ		
Creativity	High(≥103)	Low(<103)	Total
High(>97)	24 (56%)	16 (36%)	40
Low(<97)	19 (44%)	28 (64%)	47
Total	43 (100%)	44 (100%)	87

X^2 = 3.26 (Non-significant at 5% level

C. Creativity and Sex

When composite creativity was controlled for sex, there was a significant difference of proportionality between cells with more girls showing higher divergence than boys. Table VI contains the data illustrating this phenomenon.

TABLE VI. COMPOSITE CREATIVITY OF ALDINE SIXTH GRADE PUPILS CONTROLLED BY SEX

	Sex		
Creativity	Male	Female	Total
High (> 97)	23 (40%)	32 (63%)	55
Low (< 97)	34 (60%)	19 (37%)	53
Total	57 (100%)	51 (100%)	108

$X^2 = 5.54$ (Significant at 5% level)

D. Creativity and Position in the Alphabet

An unusual phenomenon developed when composite creativity scores were controlled by position in the alphabet (Table VII). The chi square

TABLE VII. COMPOSITE CREATIVITY OF ALDINE SIXTH GRADE PUPILS CONTROLLED BY POSITION IN ALPHABET

	Position in Alphabet		
Creativity	Surname begins with A-J	Surname begins with K-Z	Total
High(>97)	34 (63%)	21 (39%)	55
Low(<97)	20 (37%)	33 (61%)	53
Total	54 (100%)	54 (100%)	108

$X^2 = 6.26$ (Significant at 5% level)

statistic was significant at the .05 level, and so was the Pearson's r, which was -0.24. The roster of surnames was divided at the median name, which began with "J".

E. Other Findings

Intercorrelations between IQ scores and mathematics attitude resulted in no significant association, with r = 0.05. The same outcome developed when position in alphabet was correlated with mathematics attitude, with r = 0.00.

IV. Conclusions

The hypothesis that high divergent thinkers in sixth grade have developed negative attitudes toward mathematics as a result of the kinds of experiences they have had in school is rejected. The situation at the Aldine school is such that it offers at least a partial refutation to those who are charging that schools stifle creativity. The relatively positive attitudes that exist toward mathematics in that district, coupled with the degree of creativity there, indicates that the educational experiences undergone by elementary school pupils are not antagonistic to creativity or positive attitudes. On the other hand, there is no evidence in these data to indicate that the Aldine school experiences foster creativity and positive attitudes, either.

Though a weak positive relationship between creativity and IQ scores had been forecast, the actual result showed no association present. This outcome could well have been due to the use of Figural Form A in determining the creativity data instead of the Verbal Form. The activities included in the Figural test do not require much skill in verbalization, as do many of the IQ measurement devices. Hence, the lack of a relationship between these two sets of variables is not surprising at all.

The intercorrelations between creativity and sex and creativity and position in the alphabet were interesting and surprising. The fact that girls of Aldine's sixth grade are more creative than boys would suggest further investigation. Perhaps this phenomenon is related to the achievement curves of boys and girls, which tend to favor the female at certain stages of development.

Some hypotheses can be generated from the discovery of the relationship between creativity and the position of one's name in the alphabet. What effect does one's surname, or rather the position of the surname in the alphabet, have upon the personality of the individual? Are there practices in school, such as checking roll, handing out and taking up papers, assigned seating, etc., which tend to affect different individuals in different ways? What effect would these practices have upon attitudes, or upon creativity? These questions and others cannot be answered from this data. After all, the phenomenon could be due to chance. Further research would be helpful in finding answers.

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